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- Polymer Materials Science -

http://www.scl.kyoto-u.ac.jp/~kanaya2/index.html

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Visitor

Prof Barbara J Gabrys, The Open University, UK, 7–24 June 2002

Scope of Research

The structure and molecular motion of polymer substances are studied using mainly scattering methods such as neutron, X-ray and light with intention of solving fundamentally important problems in polymer science. The main projects are: the mechanism of structural development in crystalline polymers from the glassy or molten state to spherulites; the dynamics in disordered polymer materials including low-energy excitation or excess heat capacity at low temperatures, glass transition and local segmental motions; formation processes and structure of polymer gels; the structue and molecular motion of polyelectrolyte solutions; the structure of polymer liquid crystals.

Research Activities (Year 2002)

Presentations

Hierarchic Structure of Polymer Gels (invited), Kanaya T, Annual Meeting, the Society of Fiber Science and Technology, Japan, Tokyo, 22 May.

Crystallization of Syndiotactic Polypropylene under Shear Flow, Fukushima H, Ogino Y, Kanaya T, Nishida K, Kaji K, Annual Meeting, the Society of Fiber Science and Technology, Japan, Tokyo, 22 May.

Crystallization of Isotactic Polypropylene under Shear Flow, Ogino Y, Fukushima H, Kanaya T, Nishida K, Kaji K, Annual Meeting, the Society of Fiber Science and Technology, Japan, Tokyo, 22 May.

Observation of Speckle during Gelation Process of Poly(vinyl alcohol) Solutions, Takahashi N, Kanaya T, Nishida K, Kaji K, Annual Meeting, the Society of Fiber Science and Technology, Japan, Tokyo, 22 May.

Spinodal Decomposition Type Crystal Nucleation of Polymers, Kaji K, Nishida K, Imai M, Matsuba G, Kanaya T, International Symposium on Polymer Crystallization, Mishima, 9 - 12 June.

Homogeneous Polymer Crystallization with Microphase Separation, Nishida K, Kaji K, Konishi T, Kanaya T, Matsuba G, International Symposium on Polymer Crystallization, Mishima, 9 - 12 June.

Crystallization of Isotactic and Syndiotactic Polypropylenes under Shear Flow, Kanaya T, Fukushima H, Ogino Y, Nishida K, Kaji K, International Symposium on Polymer Crystallization, Mishima, 9 - 12 June.

Similarity between Gels and Glasses in Speckle, Takahashi N, Kanaya T, Nishida K, Kaji K, ISSP Meeting on Properties of Glasses and Glass Transition, Kashiwa, 10 July.

Bamboo Leaf Morphology of Isotactic Polypropylene Crystals, Konishi T, Nishida K, Kanaya T, Kaji K, Polymer Symposium [Kobe], the Society of Polymer Science, Japan, Kobe, 12 July.

Thermal Neutron Spin Echo Measurements on Dynamics of Polybutadiene near Glass Transition, Kanaya T, Watanabe H, Tsukushi I, Kakurai K, 3rd Workshop on Non-equilibrium Phenomena in Supercooled Fluids, Glasses, and Amorphous Materials, Pisa, 22 - 27 September.

Studies on Polymer Crystallization by Synchrotron Radiation, Kanaya T, Fukushima H, Ogino Y, Takahashi N, Nishida K, Kaji K, Autumn Meeting, the Society of Polymer Science, Japan, Fukuoka, 2 - 4 October.

Origin of Viscosity of Polyelectrolyte Solutions & Control of Higher Order Structures of Polymer Materials by a Rapid Temperature Jump Method (invited), Nishida K, 59th Symposium for Young Polymer Scientists, the Society of Polymer Science, Japan, Sakai, 16 November.

Gelation of Poly(vinyl alcohol) under Shear Flow, Takahashi N, Kanaya T, Nishida K, Nagao M, Takahashi Y, Autumn Meeting, Jpn. Soc. Neutron Sci., Kumatori, 9 December.

Grants

Kanaya T, Fukao K, Imai M, Nishida K, Preparatory mechanism of polymer crystallization, Grant-in-Aid for Scientific Research (B) (2), 1 April 2000 - 31 March 2003.

The former professor Keisuke Kaji retired on 31 March 2002.
*Promoted to professor on 1 January 2003.

Crystallization of Polymer Melts under Flow

Real time reo-DPLS and reo-SAXS

Crystallization of polymer melts under flow has been extensively studied because in most polymer processing operations such as extrusion, injection molding and fiber spinning, the molten polymers are exposed to various flows. Polymer chains are oriented under flow and crystallize with morphologies different from those under quiescent condition: the so-called shish-kebab structure. In such structure, extended chains in the direction of the applied flow act as row-nuclei (shish) and chain folded lamellae (kebab) grow on the shish in a direction perpendicular to the extension axis.

In this work we have investigated crystallization process of isotactic polypropylene (iPP), syndiotactic polypropylene (sPP) and polyethylene (PE) under flow using depolarized light scattering (DPLS), small-angle X-ray scattering (SAXS), and small-angle neutron scattering (SANS) techniques to elucidate formation mechanism of shish-kebab structure.

Photo: Ogino, Y. working on reo-DPLS instrument.

After keeping a sample at a given temperature above the melting temperature, it was cooled down to a given annealing (or crystallization) temperature, and just after reaching the temperature, a step shear was applied to the sample for a given duration, and then time-resolved DPLS and SAXS measurements were started.

Fig. 1 shows 2D DPLS pattern during crystallization process of iPP at 132 °C after a step shear. After an induction period before nucleation, a weak but sharp streak appears in a direction perpendicular to the shear flow, suggesting that shish structure appears along the flow direction. After the shish formation, kebab structure appears in time resolved SAXS pattern as shown in Fig. 2 where two spots along the flow direction are clearly observed, corresponding to a long period of the kebab structure.

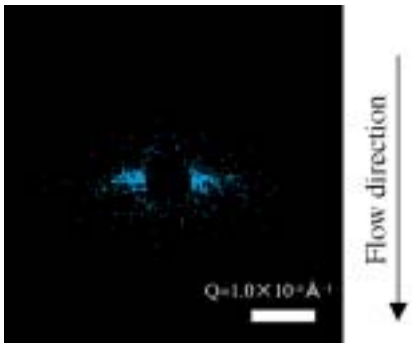

Fig. 1. 2D DPLS pattern of iPP at 1'57" after shear.

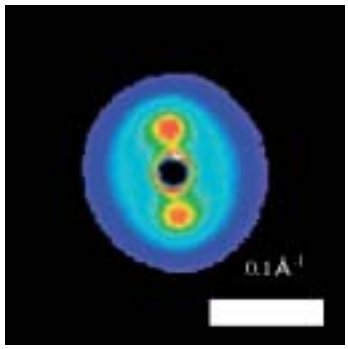

Fig. 2. 2D SAXS pattern of iPP at 4'22" after shear.

Reo-SANS

SANS measurements were also performed on elongated deuterated PE (Mw = 200,000) including a small amount of protonated PE (Mw = 2,000,000). As seen in Fig. 3, shish-kebab structure was clearly observed in 2D SANS pattern, suggesting that the shish-kebab structure formation is enhanced by the ultra-high molecular weight PE.

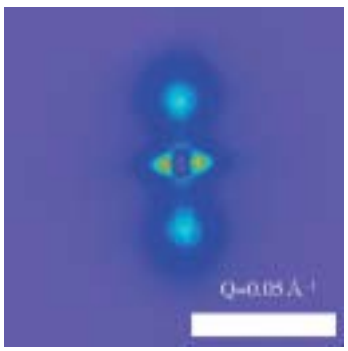

Fig. 3. 2D SANS pattern of elongated PE mixture (see text).

Nishida K, Control of higher order structures of polymer materials by a rapid temperature jump method, Industrial Technology Research Grant Program by New Energy and Industrial Technology Development Organization (NEDO) of Japan, 1 April 2001 - 31 March 2004.

Kanaya T, Ebisawa T, Tasaki S, Glass transition mechanism of polymers, Grant-in-Aid for Scientific Research (C) (2), 1 April 2001 - 31 March 2003.

Kanaya T, Nano-assembly of polymers by neutron spin echo, Grant for Researches at Dawn, Japan Atomic Energy Research Institute, 7 October 2002 - 31 March 2003.

Kanaya T, Sharma L, Production of an artificial bone material based on a hydroxyapatite polymer base, involving polyurethane hybrids, Grant-in-Aid for Scientific Research (JSPS Fellows), 15 April 2002 - 15 April 2004.

Awards

Kanaya Toshiji, SFSTJ Award, Hierarchic Structure of Polymer Gels, The Society of Fiber Science and Technology, Japan, 22 May 2002.